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Standard Recommended Practice for
OPERATING LIGHT- AND WATER-EXPOSURE APPARATUS (CARBON-ARC TYPE) FOR EXPOSURE OF NONMETALLIC MATERIALS[1]

This Standard is issued under the fixed designation G 23; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

$^{\epsilon}$ NOTE—Table 1 was editorially corrected in April 1974.

1. Scope

1.1 This recommended practice covers the basic principles and standard operating procedure for light- and water-exposure apparatus employing a carbon-arc type light source.

1.2 This recommended practice does not specify the exposure conditions best suited for the material to be tested, but it is limited to the method of obtaining, measuring, and controlling the conditions and procedures of the exposure. Sample preparation, test conditions, and evaluation of results are covered in ASTM methods or specifications for specific materials.

NOTE 1—The values stated in U.S. customary units are to be regarded as the standard.

NOTE 2—See the following for recommendations on specific materials:

ASTM Recommended Practice D 822, for Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products.[2]

ASTM Recommended Practice D 529, for Accelerated Weathering Test of Bituminous Materials.[3]

ASTM Recommended Practice D 1499, for Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics.[4]

ASTM Recommended Practice D 750, for Operating Light- and Weather-Exposure Apparatus (Carbon-Arc Type) for Artificial Weather Testing of Rubber Compounds.[5]

2. Significance

2.1 Several types of apparatus with different exposure conditions are available for use. No single operating procedure for light- and water-exposure apparatus can be specified as a direct simulation of natural exposure. This recommended practice does not imply expressly or otherwise an accelerated weathering test.

2.2 Since the natural environment varies with respect to time, geography, and topography, it may be expected that the effects of natural exposure will vary accordingly. All materials are not affected equally by the same environment. Results obtained by the use of this recommended practice shall not be represented as equivalent to those of any natural weathering test until the degree of quantitative correlation has been established for the material in question.

2.3 Variations in results may be expected among instruments of different types or when operating conditions among similar type instruments vary within the accepted limits of this recommended practice. Therefore, no reference shall be made to results from use of this recommended practice unless accompanied by Section 5 or unless otherwise specified in a referenced procedure.

3. Apparatus

3.1 The apparatus employed shall utilize one or two carbon-arc lamps as the source of radiation, and shall be one of the following twelve general types, or their equivalent. In the following commercial descriptions of the

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[1] This recommended practice is under the jurisdiction of ASTM Committee G-3 on Deterioration of Nonmetallic Materials.

Current edition effective March 21, 1969. Originally issued 1942 as E 42. Replaces E 42 – 65. Redesignated G 23 in 1970.

[2] *1974 Annual Book of ASTM Standards*, Part 27.

[3] *1974 Annual Book of ASTM Standards*, Part 15.

[4] *1974 Annual Book of ASTM Standards*, Part 35.

[5] *1974 Annual Book of ASTM Standards*, Part 37.

twelve types, the term "cycle" is defined as the time intervals of light and water spray that are specified differently according to the different testing materials (see 4.6 and 4.7).

3.1.1 *Type A*—Single enclosed carbon-arc lamp apparatus,[6] 30-in. (762-mm) diameter specimen drum, automatic control of temperature and cycle with 1 rpm of the specimen drum, and no automatic control of humidity.

3.1.2 *Type AH*—Same as Type A, except with automatic control of humidity.

3.1.3 *Type B*—Single enclosed carbon-arc lamp apparatus,[6] 30-in. diameter specimen drum, automatic control of temperature and cycle with 3 rph of the specimen drum, and no automatic control of humidity.

3.1.4 *Type C*—Single enclosed carbon-arc lamp apparatus,[6] 30-in. diameter specimen drum, no automatic control of temperature or humidity, and cycle controlled by 3 rph of the specimen drum.

3.1.5 *Type D*—Twin enclosed carbon-arc lamp apparatus,[6] 30-in. diameter specimen drum, automatic control of temperature and cycle with 1 rpm of the specimen drum, and no automatic control of humidity.

3.1.6 *Type DH*—Same as Type D, except with automatic control of humidity.

3.1.7 *Type E*—Single open-flame sunshine carbon-arc lamp apparatus,[6] 37$^3/_4$-in. (959-mm) diameter specimen rack, automatic control of temperature and cycle with 1 rpm of the specimen rack, and no automatic control of humidity.

3.1.8 *Type EH*—Same as Type E, except with automatic control of humidity.

3.1.9 *Type F*—Single open-flame sunshine carbon-arc lamp apparatus,[6] 37$^3/_4$-in. diameter specimen rack with vertical specimen mounting, automatic control of cycle with 0.5 rph of the specimen rack, and no automatic control of temperature or humidity.

3.1.10 *Type G*—Single open-flame sunshine carbon-arc lamp apparatus,[6] 37$^3/_4$-in. effective diameter specimen rack with angular specimen mounting, automatic control of cycle with 0.5 rph of the specimen rack, and no automatic control of temperature or humidity.

3.1.11 *Type H*—Single enclosed carbon-arc lamp apparatus,[6] 20-in. (508-mm) diameter specimen rack, automatic control of temperature and cycle with 1 rpm of the specimen rack, and manual regulation of humidity.

3.1.12 *Type HH*—Same as Type H, except with automatic control of humidity.

3.2 The apparatus shall consist of a suitable frame within which is located a test chamber, and necessary compartments for housing control and regulating equipment.

3.3 Provision shall be made for mounting or supporting the test specimens in a circular rack or drum which is rotated around the arc or arcs, providing uniform distribution of the radiation on all specimens.

3.4 Adequate ventilation shall be provided in the test chamber to prevent contamination of the specimens from products of combustion of the arc.

3.5 The apparatus shall include equipment necessary for measuring and controlling the following:

3.5.1 Arc current,

3.5.2 Arc voltage,

3.5.3 Black-panel temperature (Note 3),

3.5.4 Water-spray temperature,

3.5.5 Operating schedule or cycle,

3.5.6 Exposure time, and

3.5.7 Relative humidity (Types AH, DH, EH, and HH only).

3.6 Types AH, DH, EH, and HH are additionally equipped with a thermostatically actuated, electrically operated vaporizing unit for adding moisture to the air as it passes through the conditioning chamber in the base section of the apparatus prior to its entry into the test chamber. Relative humidity of the air in the test chamber for the purpose of this recommended practice is calculated from the readings of wet- and dry-bulb thermometers, either indicating or recording, whose sensing portion is located in the air stream at its point of exit from the test chamber.

3.7 The black-panel thermometer unit shall consist of a 20-gage stainless-steel panel, 2$^3/_4$ by 5$^7/_8$ in. (70 by 149 mm), to which is mechanically fastened a stainless-steel bimetallic dial-type thermometer. This thermometer shall have a stem $^5/_{32}$ in. (3.9 mm) in diameter with a 1$^3/_4$-in. (44.4-mm) dial. The sensitive portion extending 1$^1/_2$ in. (38 mm) from the end of the stem shall be located in the center of the panel 2$^1/_2$ in. (64 mm) from the top and 1$^7/_8$ in. (48 mm) from the bottom of the panel.

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[6] Available from the Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, Ill. 60613.

The face of the panel with the thermometer stem attached shall be finished with two coats of a baked-on black enamel selected for its resistance to light and water. Control of the black-panel temperature shall be accomplished preferably by a continuous flow of air over the specimen at a controlled temperature, but an on-off flow of room-temperature air is permissible (Note 3).

NOTE 3—Types B, C, F, and G apparatus may require supplementary ventilation to meet this requirement.

3.8 Detail requirements and operating conditions of the twelve types of apparatus are given in Table 1 and Figs. 1 to 5.

4. Procedure

4.1 Prepare specimens of a suitable size and shape for mounting in the drum or rack of the apparatus in accordance with the detailed requirements specified for the material to be tested.

4.2 Mount the test specimens, except those whose shape or other physical characteristics make it impractical, vertically both above and below the horizontal center line of the source of radiation, except Type G, where the angle of mounting conforms to the equipment. In order to provide uniform exposure conditions over their surface, change the position of the test specimens daily. Rotate the specimen position in the drum or rack in four steps, employed in the same sequence, from upper to lower specimen row and inverted in both specimen rows. If the time of exposure is less than 4 days (the time required for the four position steps in the exposure cycle), all specimens in a given series should be positioned at the same level, either upper or lower (provided that sufficient space is available).

4.3 Where physical characteristics do not permit suspension of specimens in a vertical position, expose then horizontally on a rack $6^1/_2$ in. (165 mm) below the horizontal center of the source or sources of radiation. Mount the specimens on a circular horizontal rack equipped with turntables, so that each specimen is rotated on its own axis as all of the specimens are rotated around the source or sources of radiation.

4.4 Temperature measurement and control shall be based on the black-panel thermometer unit. Support the panel with the thermometer attached in the specimen drum or rack in the same manner as the test specimens so that it will be subjected to the same influences. If possible, read black-panel temperatures through the window in the test chamber without opening the door on Types A, AH, B, D, DH, E, EH, H, and HH apparatus, allowing sufficient time after starting up or after wetting, due to water spray, to reach equilibrium. On Types C, F, and G apparatus, read the temperature, through the curtains or by removing the top, at the point just prior to the entry of the black panel into the specimen spray. Unless other temperatures and tolerances are specified in the applicable ASTM method or detailed material specifications, the black-panel temperature shall be 63 ± 5 C (145 ± 9 F) during the light-on-without-water-spray period of the test cycle.

4.5 The water from the specimen spray shall strike the test specimens in the form of a fine spray equally distributed over the test specimens. Unless otherwise specified in the applicable ASTM method or detailed material specification, the water pressure, number, and type of nozzles shall be in accordance with the detailed requirements for the various types of apparatus as indicated in Figs. 1 to 5. The pH of the water shall be 6.0 to 8.0 and the water shall not leave an objectionable deposit or stain on the specimens after continued exposure in the apparatus. The temperature of the water shall be 16 ± 5 C (60.0 ± 9 F), and recirculation shall not be permitted unless the recirculated water meets the above requirements. For certain test materials or for water systems fabricated of certain materials (for example, aluminum), the use of deionized or distilled water may be advisable.

4.6 Unless otherwise mutually agreed upon or specified by the applicable ASTM or detailed material specification, operate Types A, D, and E, and Types AH, DH, EH, H, and HH with the humidifier off, with a cycle cam that provides 102 min light followed by 18 min light and spray. In these types of apparatus the specimen spray is operated intermittently; and the specimens, when the spray is on, pass through the spray once in each minute or revolution of the drum or rack. In Types B, C, F, and G apparatus allow the water spray to be on continuously, and the interval and duration of the period during which the specimen is in the spray is a function of the rotation of the specimen drum or rack.

NOTE 4—This operating schedule is intended to combine light- and water-spray exposure in a way that permits operation of the various types of carbon-arc-type apparatus that are in common use on approximately the same schedule, in order to promote better correlation between laboratories. For maximum uniformity, a schedule of approximately 20 h, 5 days per week, is recommended, a 2-day rest period being included as a desirable part of the schedule. This schedule is not necessarily to be considered as preferable to any other schedule that combines the effects of light alone, light and water, water alone, and rest periods in a sequence that produces more desirable results for specific types of materials.

4.7 When mutually agreed upon or called for by the applicable ASTM method or detailed material specification, operate Types AH, DH, EH, H, and HH apparatus with automatic control of humidity, unless otherwise specified or agreed upon, on a cycle of 102 min of light only followed by 18 min light with spray repeating for a total of 18 h. Follow the 18-h period by 6 h without light or spray. During the 18-h period of light and spray, the black-panel temperature, except when the specimen spray is on, shall be 63 ± 5 C (145 ± 9 F), and the relative humidity of the air shall be 50 ± 5 percent. During the 6-h period of darkness without spray, the black-panel temperature shall be 24 ± 2 C (75 ± 5 F), and the relative humidity of the air in the test chamber shall be 95 ± 4 percent. In the description of this cycle (see 5.1.1), include the number of 18-h light periods and 6-h dark periods.

4.8 Replace filters (globes and flat panes) after 2000 h of use, or when pronounced discoloration or milkiness develops, whichever occurs first. Clean filters each day by washing with detergent and water. It is recommended that filters be replaced on a rotating replacement schedule in order to provide more uniformity over long periods of exposure. Suggested schedules for Types D, DH, E, EH, F, and G apparatus are replacement of one half of the globes or filter panes each 1000 h of operation.

4.9 Unless otherwise specified in the applicable ASTM method or detailed material specifications, operate Types E, F, and G apparatus with the filters in place and with the carbon electrodes specified in Table 1 and Footnote *c*. If operated without filters or with other types of carbon electrodes, state this in the report of test results.

5. Report

5.1 The report shall include the following:

5.1.1 Type and model of exposure device,

5.1.2 Type of light source,

5.1.3 Age of filters,

5.1.4 Flux density at sample location (watts per square meter), (Note 5),

5.1.5 Spectral irradiance at sample location (watts per square meter, micrometer),

5.1.6 Elapsed exposure time,

5.1.7 Light/dark-water-humidity cycle employed,

5.1.8 Operating black-panel temperature,

5.1.9 Operating relative humidity,

5.1.10 Type of spray water,

5.1.11 Type of spray nozzle, and

5.1.12 Specimen relocation procedure.

NOTE 5—When direct measurement of flux density and spectral irradiance can not be made, data supplied by the manufacturer shall be substituted.

TABLE 1 **Detail Requirements and Operating Conditions of Light- and Water-Exposure Apparatus**

	Type[a]							
	A, AH	B	C	D, DH	E, EH	F	G	H, HH
Line voltage, V:								
208 to 250	X	X	X	X	X	X	X	X
Arc voltage, V:								
120 to 145	X	X	X	X				X
48 to 52					X	X	X	
Arc current, A:								
15 to 17, ac	X	X	X	X				X
58 to 62, ac					X	X	X	
12 to 14, dc	X	X	X	X				X
58 to 62, dc					X	X	X	
Carbon electrodes, upper, in. (mm):								
½ by 12 (12.7 by 304.8) neutral cored or solid[b]	X	X	X	X				X
⅞ (22.2) by 12 copper-coated sunshine[c]					X	X	X	
Carbon electrodes, lower, in. (mm):								
½ by 4 (101.6) neutral cored or solid[b]	X	X	X	X				X
½ by 12 copper-coated sunshine[c]					X	X	X	
Filter, globe, or flat pane for removing undesired wavelengths of radiation and preventing byproducts of combustion of the arc from contaminating the specimens:								
Globe of optical, heat-resistant glass with cut-off at 2750 A, with an increase in transmission to 91 percent at 3700 A[d]	X	X	X	X				X
Flat panes of optical, heat-resistant glass with cut-off at 2550 A, with an increase in transmission to 91 percent at 3600 A[e]					X	X	X	
Diameter of specimen rack or drum, in (mm):								
20 (508)								X
30 (762)	X	X	X	X				
37¾ (959)					X	X		
33¾ (857) at top and bottom, 39 (991 in center							X	
Speed of rotation of specimen drum or rack:								
1 rpm	X			X	X			X
3 rph		X	X					
0.5 rph						X	X	
Automatic arc feed:								
Solenoid-operated	X	X	X	X				X
Motor-operated					X	X	X	
Spray (see figure indicated for arrangement, location, and capacity)	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5

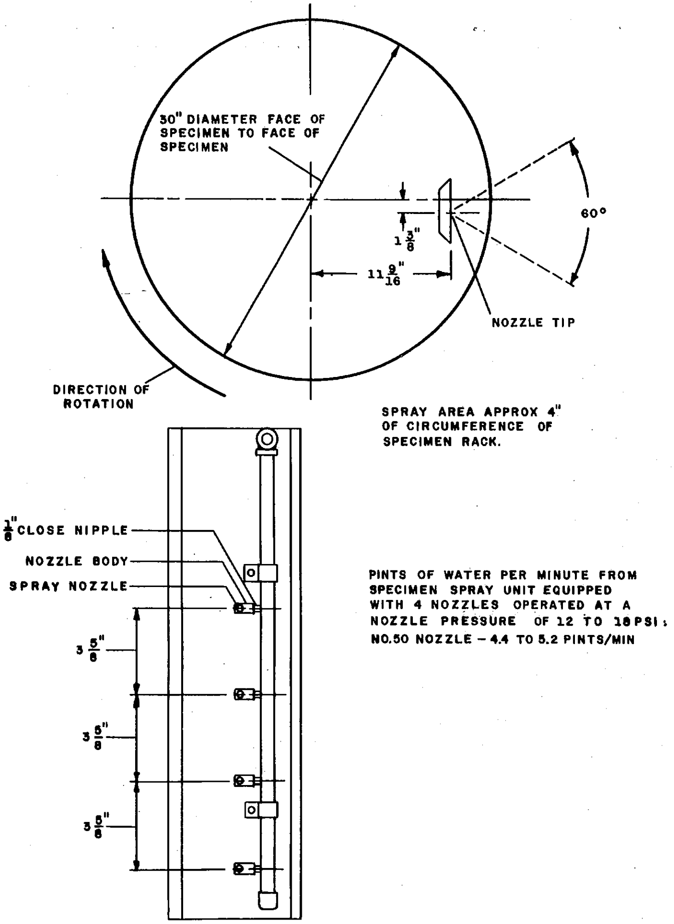
[a] "X" in column indicates application to that type of apparatus.

[b] No. 70 Solid Carbon Electrodes and No. 20 Cored Carbon Electrodes,[6] or equivalent.

[c] No. 22 Copper-Coated Sunshine Carbon Electrodes and No. 13 Copper-Coated Sunshine Carbon Electrodes,[6] or equivalent.

[d] No. 9200-PX Globe,[6] or equivalent.

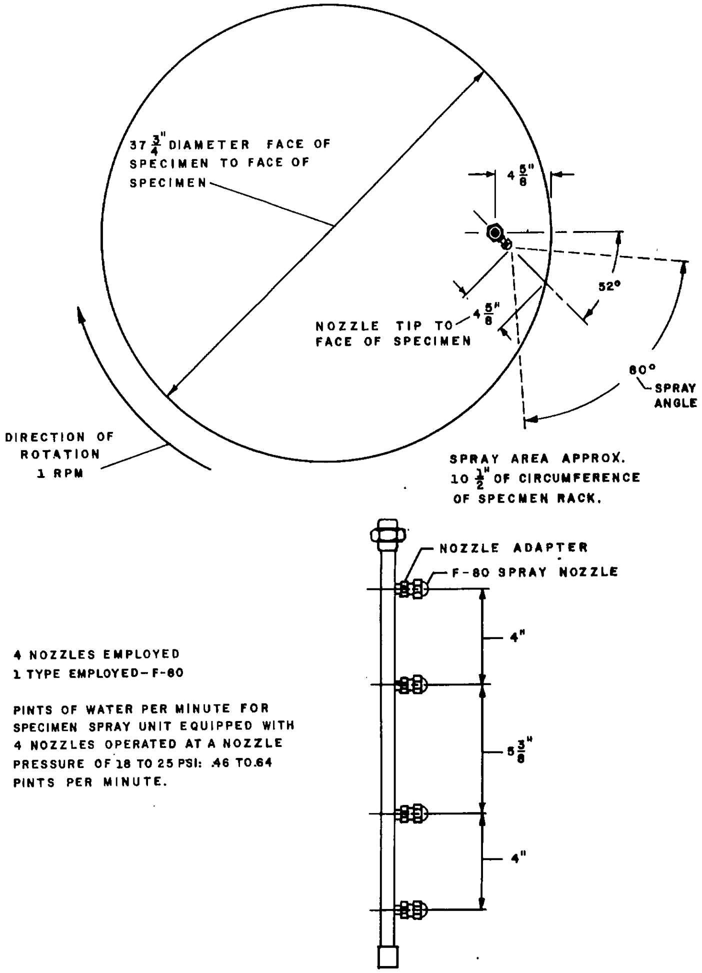
[e] No. EX-552-22 Corex D Filter Panes,[6] or equivalent.


30" DIAMETER FACE OF SPECIMEN TO FACE OF SPECIMEN
$1\frac{3}{8}$"
$11\frac{9}{16}$"
60°
NOZZLE TIP
DIRECTION OF ROTATION
SPRAY AREA APPROX 4" OF CIRCUMFERENCE OF SPECIMEN RACK.
$\frac{1}{8}$" CLOSE NIPPLE
NOZZLE BODY
SPRAY NOZZLE
$3\frac{5}{8}$"
$3\frac{5}{8}$"
$3\frac{5}{8}$"
PINTS OF WATER PER MINUTE FROM SPECIMEN SPRAY UNIT EQUIPPED WITH 4 NOZZLES OPERATED AT A NOZZLE PRESSURE OF 12 TO 18 PSI:
NO.50 NOZZLE – 4.4 TO 5.2 PINTS/MIN

Metric Equivalents

in.	1/8	1 3/8	3 5/8	4	11 9/16	30	12 to 18 psi	4.4 to 5.2 pt
mm	3.3	34.9	92.1	101.6	293.2	762	83 to 124 kPa	2.5 to 2.9 dm^3

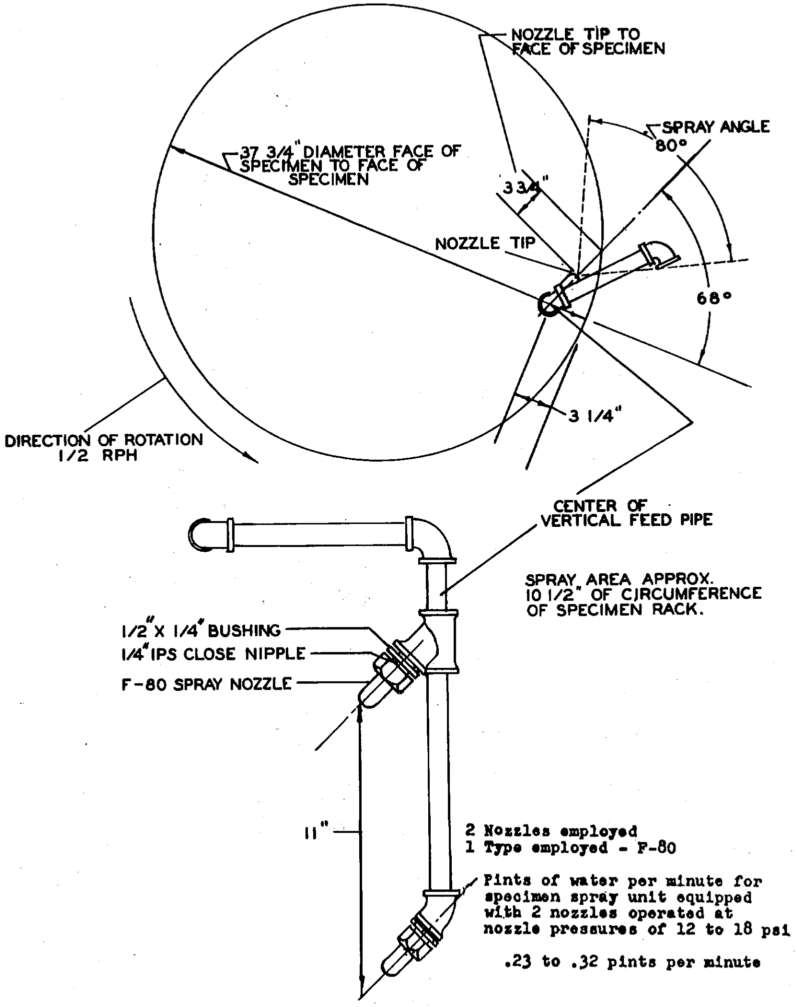
FIG. 1 Specimen Spray Arrangement for Types, A, AH, B, C, D, and DH Apparatus.


37 3/4" DIAMETER FACE OF SPECIMEN TO FACE OF SPECIMEN
4 5/8"
52°
NOZZLE TIP TO FACE OF SPECIMEN 4 5/8"
80° SPRAY ANGLE
DIRECTION OF ROTATION 1 RPM
SPRAY AREA APPROX. 10 1/2" OF CIRCUMFERENCE OF SPECMEN RACK.
NOZZLE ADAPTER
F-80 SPRAY NOZZLE
4"
5 3/8"
4"
4 NOZZLES EMPLOYED
1 TYPE EMPLOYED-F-80
PINTS OF WATER PER MINUTE FOR SPECIMEN SPRAY UNIT EQUIPPED WITH 4 NOZZLES OPERATED AT A NOZZLE PRESSURE OF 18 TO 25 PSI: .46 TO .64 PINTS PER MINUTE.

Metric Equivalents

in.	4	4 5/8	5 3/8	10 1/2	37 3/4	18 to 25 psi	0.46 to 0.64 pt
mm	101.6	117.5	136.5	266.7	959	124 to 172 kPa	0.26 to 0.36 dm^3

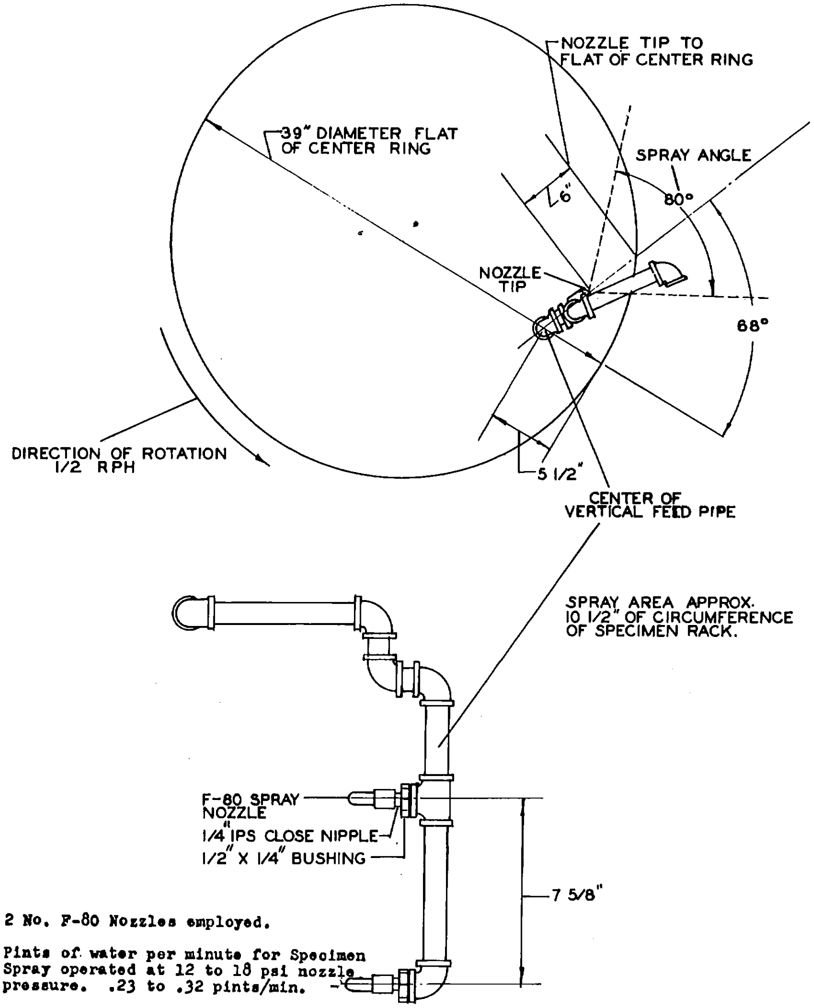
FIG. 2 Specimen Spray Arrangement for Types E and EH Single Open-Flame Sunshine Carbon-Arc Lamp Apparatus.


NOZZLE TIP TO FACE OF SPECIMEN
SPRAY ANGLE 80°
37 3/4" DIAMETER FACE OF SPECIMEN TO FACE OF SPECIMEN
3 3/4"
NOZZLE TIP
68°
3 1/4"
DIRECTION OF ROTATION 1/2 RPH
CENTER OF VERTICAL FEED PIPE
SPRAY AREA APPROX. 10 1/2" OF CIRCUMFERENCE OF SPECIMEN RACK.
1/2" X 1/4" BUSHING
1/4" IPS CLOSE NIPPLE
F-80 SPRAY NOZZLE
11"
2 Nozzles employed
1 Type employed - F-80
Pints of water per minute for specimen spray unit equipped with 2 nozzles operated at nozzle pressures of 12 to 18 psi
.23 to .32 pints per minute

Metric Equivalents

in.	$^1/_4$	$^1/_2$	$3^1/_4$	$3^3/_4$	$10^1/_2$	11	$37^3/_4$	12 to 18 psi	0.23 to 0.32 pt
min.	6.4	12.7	82.6	92.3	266.7	279.4	959	83 to 124 kPa	0.13 to 0.18 dm^3

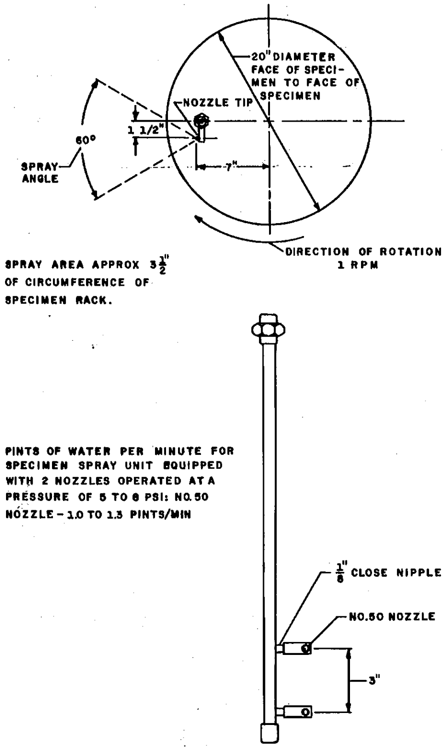
FIG. 3 Specimen Spray Arrangement for Type F Single Open-Flame Sunshine Carbon-Arc Lamp Apparatus with Vertical Specimen Mounting.


NOZZLE TIP TO FLAT OF CENTER RING
39" DIAMETER FLAT OF CENTER RING
SPRAY ANGLE
80°
6"
NOZZLE TIP
68°
DIRECTION OF ROTATION 1/2 RPH
5 1/2"
CENTER OF VERTICAL FEED PIPE
SPRAY AREA APPROX. 10 1/2" OF CIRCUMFERENCE OF SPECIMEN RACK.
F-80 SPRAY NOZZLE
1/4" IPS CLOSE NIPPLE
1/2" X 1/4" BUSHING
7 5/8"
2 No. F-80 Nozzles employed.
Pints of water per minute for Specimen Spray operated at 12 to 18 psi nozzle pressure. .23 to .32 pints/min.

Metric Equivalents

in.	$^1/_4$	$^1/_2$	$5^1/_2$	6	$7^5/_8$	$10^1/_2$	39	12 to 18 psi	0.23 to 0.32 pt
mm.	6.4	12.7	139.7	152.4	193.7	266.7	991	0.84 to 1.3 kgf/cm^2	0.13 to 0.18 dm^3

FIG. 4 Specimen Spray Arrangement for Type G Single Open-Flame Sunshine Carbon-Arc Lamp Apparatus with Angular Specimen Mounting.


20" DIAMETER FACE OF SPECIMEN TO FACE OF SPECIMEN
NOZZLE TIP
1 1/2"
60°
SPRAY ANGLE
7"
DIRECTION OF ROTATION 1 RPM
SPRAY AREA APPROX 3½" OF CIRCUMFERENCE OF SPECIMEN RACK.
PINTS OF WATER PER MINUTE FOR SPECIMEN SPRAY UNIT EQUIPPED WITH 2 NOZZLES OPERATED AT A PRESSURE OF 5 TO 8 PSI: NO. 50 NOZZLE – 1.0 TO 1.3 PINTS/MIN
⅛" CLOSE NIPPLE
NO. 50 NOZZLE
3"

Metric Equivalents

⅛ in.	3.2 mm
1½ in.	38.1 mm
3 in.	76.2 mm
3½ in.	88.9 mm
20 in.	508 mm
5 to 8 psi	34 to 55 kPa
1.0 to 1.3 pt	0.56 to 0.73 dm^3

FIG. 5 Specimen Spray Arrangement for Types H and HH Single Enclosed Carbon-Arc Lamp Apparatus.

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